PARTICULATE AND GASEOUS EMISSIONS FROM PRESCRIBED FIRES IN A PROTECTED NATURAL AREA

Blanco-Alegre C.[1], Calvo A.I.[1], Castro A.[1], Oduber F.[1], Alves C.[2], Coz E.[3], Nunes T.[2], Valbuena L.[4], Cárdenas R.M.[4], Castedo F.[4], Fraile R.[1]
[1]Department of Physics, IMARENAB University of León, 24071 León, Spain
[2]Centre for Environmental and Marine Studies (CESAM), Department of Environment and Planning, University of Aveiro, 3810-193Aveiro, Portugal
[3]Centre for Energy, Environment and Technology Research (CIEMAT), Department of the Environment, Madrid, Spain
[4]Department of Biodiversity and Environmental Management, Area of Ecology, University of León, 24071 León, Spain
*roberto.fraile@unileon.es

INTRODUCTION

In Europe, forest fires have increased in number and surface over the last 50 years and the Mediterranean area is especially affected. Shrub fires produce large amounts of atmospheric carbonaceous material and greenhouse gases greatly affecting air quality and climate (Jacobson, 2001). In particular, elemental carbon (EC) is a strong absorber of solar radiation, playing an important role in global warming. On the other hand, organic carbon (OC) primarily scatters solar radiation opposing the heating effect of EC (Boreddy et al., 2017; Yao et al., 2016). This study can have noteworthy implications not only for the air quality itself, but also for the ecological aspects of the environment due to the recent finding about the narrow relation between the smoke produced in shrub fires and the seeds germination processes after the fire (Bargmann et al., 2014). Besides, this work is the result of a field campaign, not a laboratory study, with real, not simulated, conditions.

STUDY AREA

Scrubland prescribed fires were carried out on October, 3rd and 4th, 2016 in La Cueta, León (NW Spain). The area is within a protected natural area ("Valle de San Emiliano").

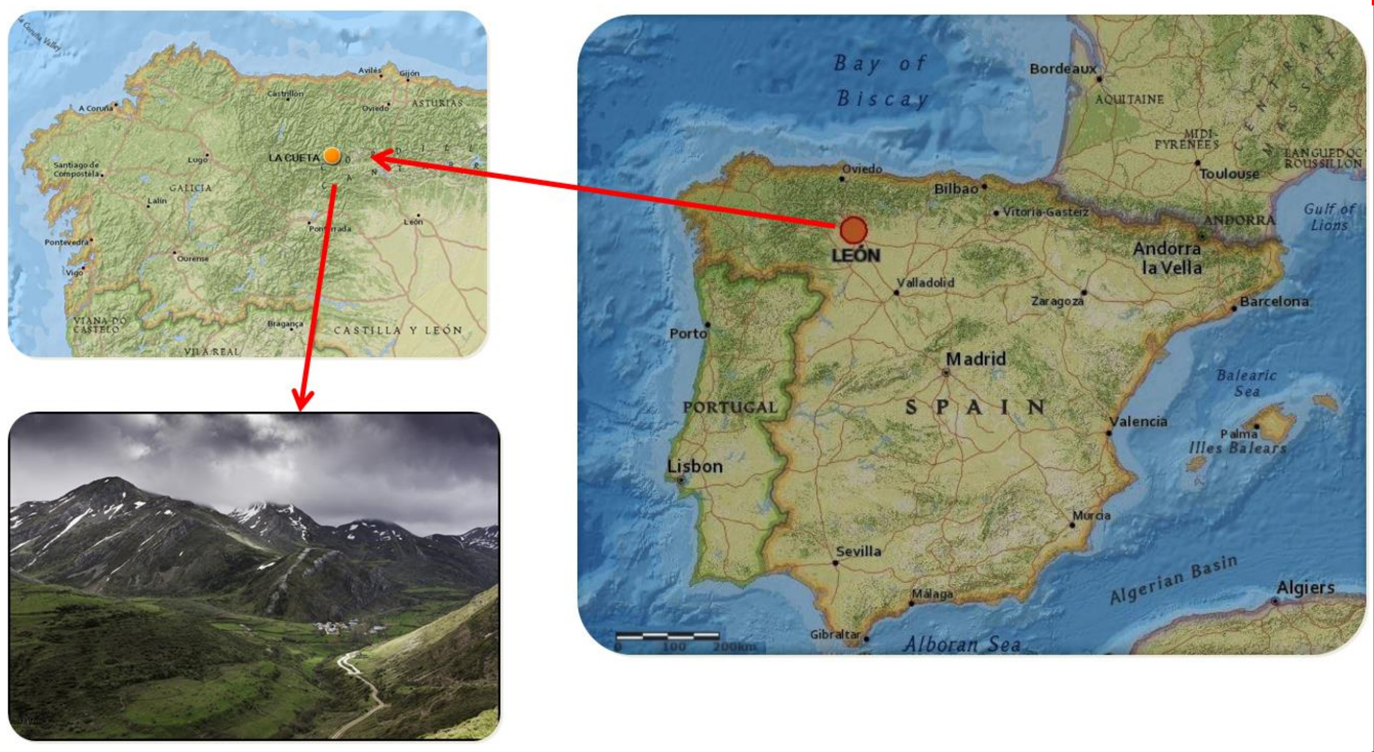

Figure 1. La Cueta in the NW Iberian Peninsula and surroundings of the sampling site.

METHODOLOGY

The air measuring equipment was placed between 3 and 10 m upwind from the fire.

~1000 m² were burned in each plot

Two of the major scrub species in the area were burned:

Calluna vulgaris

Genista hispanica subsp. *occidentalis*

SAMPLING INSTRUMENTS USED

A low volume Echo PM TECORA to collect $PM_{2.5}$ onto quartz filter

A Gent stacked filter unit sampler to collect PM_{10} onto polycarbonate filters (0.2 µm pore size)

A thermocouple network to register the surface T evolution during fires

TEDLAR bags for smoke sampling

CO and CO_2 Combo IAQ Meter

A fire patrol and personnel of the Junta de Castilla y León were present for the fire ignition and control.

The plots had been previously delimited with firewalls

Before each experiment, the boarders of the plots were sprayed with water to delimit the burning, so the humidity near the equipment increased.

RESULTS

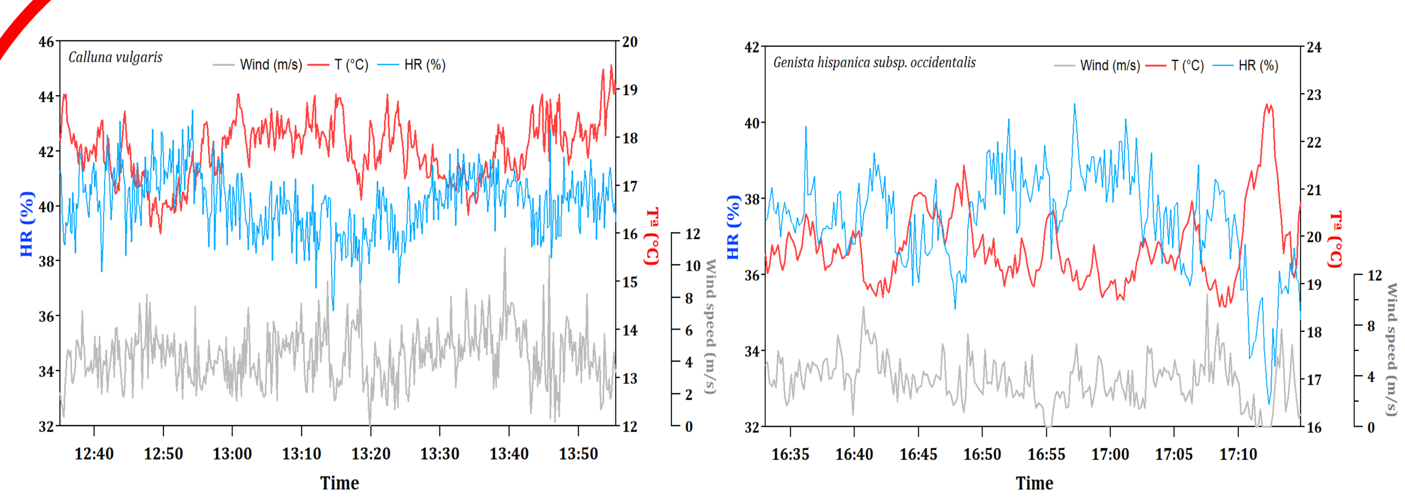

Figure 2. Meteorological conditions for *Calluna* and *Genista* burning. Data provided by: Molina J.R, Rodríguez and Silva F., Laboratorio de Incendios Forestales. Universidad de Córdoba (LABIF-UCO).

Table 1. Summary of mean meteorological conditions in *Calluna* and *Genista* burning. Data provided by: Molina J.R, Rodríguez and Silva F., Laboratorio de Incendios Forestales. Univ. de Córdoba, LABIF-UCO).

Calluna vulgaris				*Genista hispanica* subsp. *occidentalis*			
Altitude (m)	Wind Speed (m/s)	T (°C)	RH (%)	Altitude (m)	Wind Speed (m/s)	T (°C)	RH (%)
1395	4.3±1.7	17.7±0.6	40.1±1.1	1534	3.6±1.8	19.7±0.8	37.4±1.3

Modified combustion efficiency (**MCE**) is used to evaluate the completeness of combustion; it can be considered that >90% of the carbon combusted in a fire is emitted in the form of CO_2 and CO.

- *Calluna vulgaris*: MCE>90 (91.4) **FLAMING PHASE**
- *Genista hispanica* subsp. *occidentalis:* MCE<90 (85.3) **SMOULDERING PHASE**

$$MCE = \frac{[CO_2]}{[CO_2] + [CO]}$$

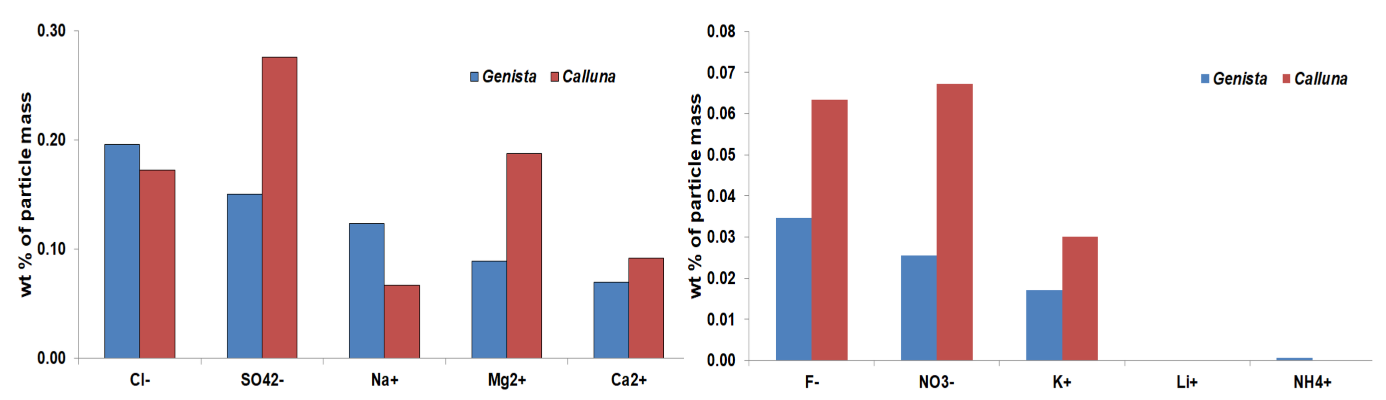

Figure 4. Water-soluble ions (expressed as wt % of particle mass) in *Calluna* and *Genista* burning.

Table 2 . Characteristics of the solid biomass fuels (*Calluna* and *Genista*).

SPECIES		Humidity (%)	Volatile	Ash (815ºC)	Ash (550ºC)	C (%)	H (%)	N (%)	S (%)	HCV (kcal/kg)	LCV (kcal/kg)
Genista	s/dry	-	80.2	1.58	1.86	53.2	6.53	1.19	0.08	5238	4882
	s/r a.r*	10.1	72.1	1.42	1.67	47.8	6.99	1.07	0.07	4710	4330
Calluna	s/dry	-	77.5	1.74	1.98	53.3	6.34	0.9	0.09	5240	4895
	s/ a.r*	9.2	70.4	1.58	1.8	48.4	6.78	0.82	0.08	4759	4391

*Sample received without original humidity. **HCV (High Calorific Value); LCV (Low Calorific Value)

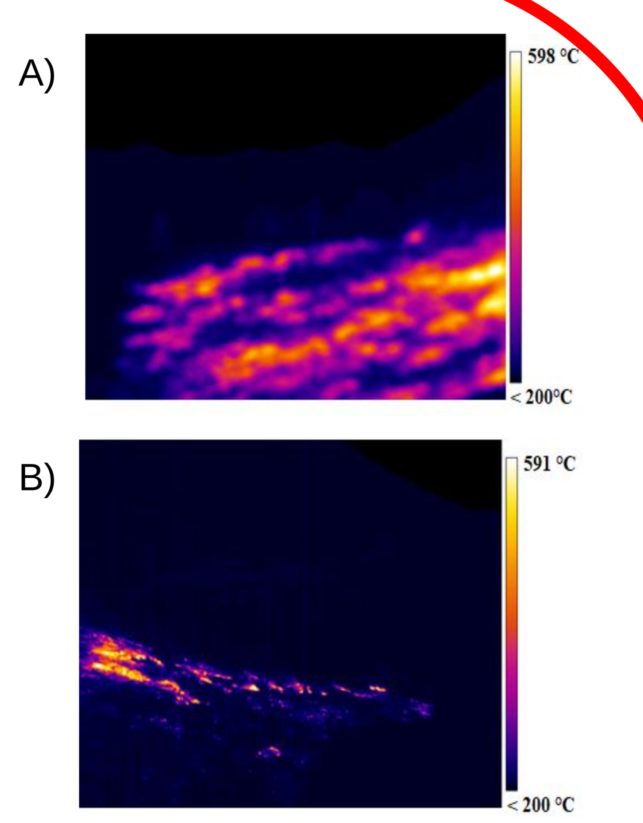

Figure 5. Images of *Calluna* (A) and *Genista* (B) burning using a thermal camera. Data provided by: Molina J.R, Rodríguez and Silva F., Laboratorio de Incendios Forestales. Universidad de Córdoba (LABIF-UCO).

Emission Factor (**EF**) is defined as the amount of a compound released per amount of dry fuel consumed, expressed in units of g kg⁻¹.

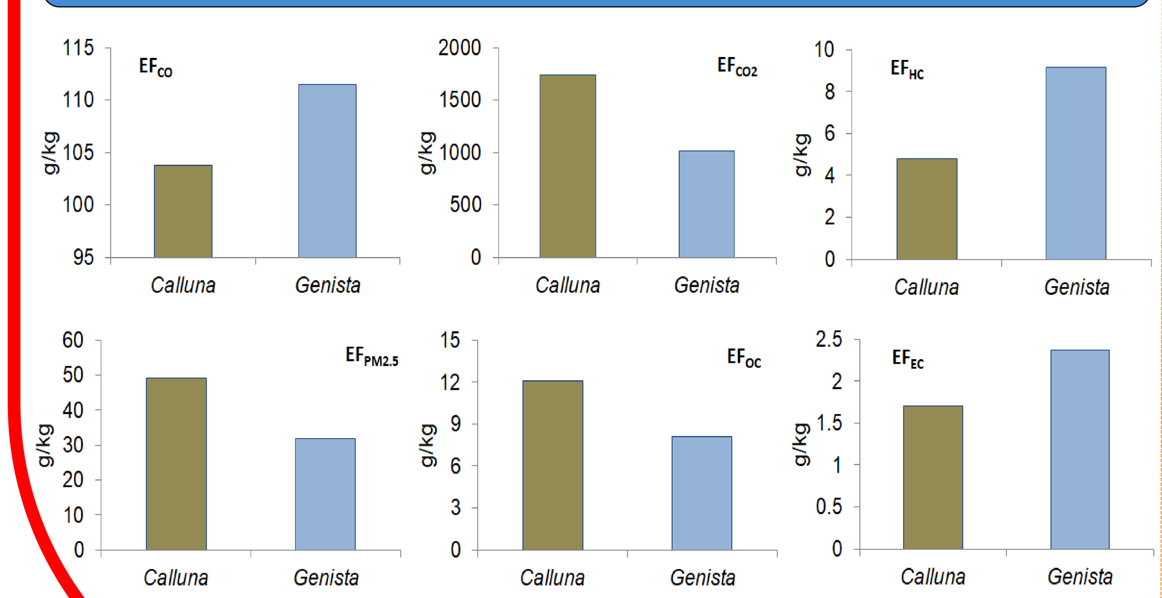

Figure 3. Emission Factor (EF) of CO, CO_2, HC, $PM_{2.5}$, OC and EC during *Calluna* and *Genista* burning.

Figure 6. Images of prescribed fires of *Calluna* and *Genista species*.

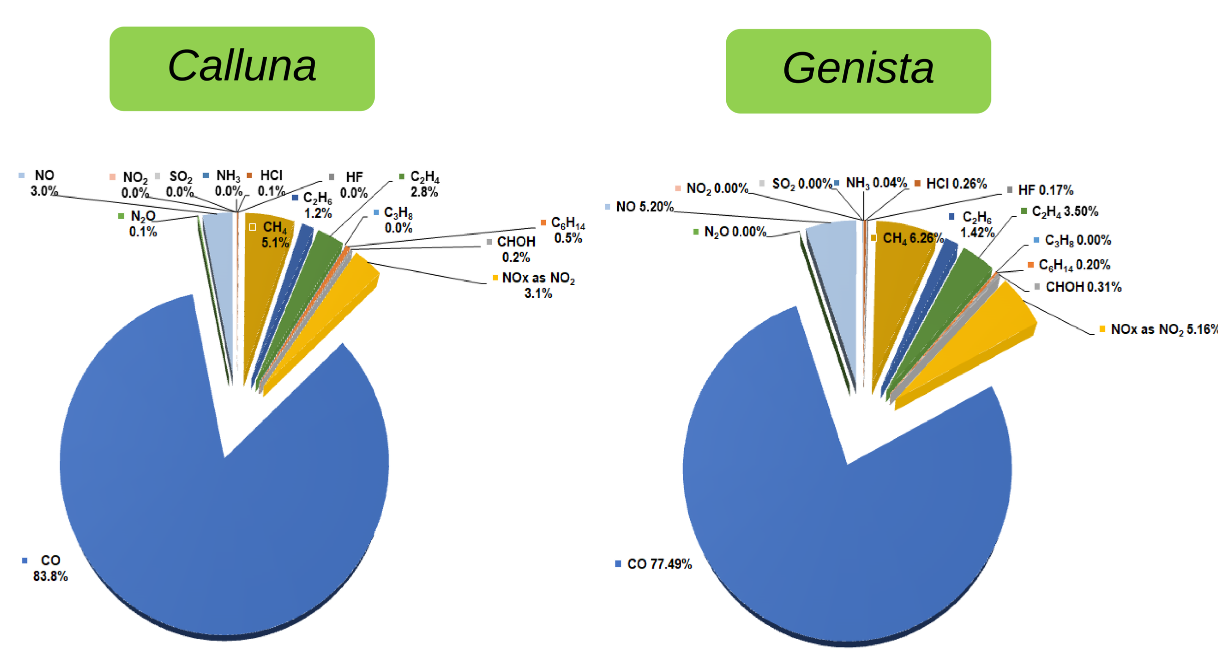

Figure 7. Percentages of the different minority gases identified by a FTIR through the analysis of the TEDLAR bags samples for *Calluna* and *Genista* burnings (CO_2 has been excepted)

CONCLUSIONS

- For *Calluna*, EC+OC represents 28.1% of PM_{10}, while for *Genista* it represents 32.9%.
- $CO+CH_4+NO+C_2H_4$ represent more than 97.6 of gases emitted in *Calluna* and *Genista* burnings.
- Water soluble ions in *Calluna* presents higher concentrations than *Genista* (except Cl^-).
- Cl^-, SO_4^{2-}, Na, Mg^{2+} and Ca^{2+} are more than 80% of the ion emissions in both species burning.
- EF_{CO2} values in *Calluna* are similar to Amazonian forest clearing fire (Soares Neto et al., 2009).

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